

Performance Analysis of LEACH, SEP and ZSEP under the Influence of Energy

Sulekha Kumari

Department of ECE, Mody University of Science and Technology, Laxmangarh, Sikar, Rajasthan, India

Abstract— For any wireless sensor network to work effectively and efficiently in any kind of environment, preventing it from any kind of attack internally and externally, it is very important to setup the network keeping in mind the various parameters which must be considered. Some of the most important parameters are energy consumption, throughput, network area and initial energy that we give to the network. Another most important thing is the protocol that we use in the network. In this paper, the wireless sensor network is setup using LEACH (Low Energy Adaptive Clustering Hierarchy), then SEP (Stable Election Protocol) and then ZSEP (Zonal Stable Election Protocol) and then initial energy that we give to the network is varied keeping the network area constant. The effect of change in initial energy is studied on these protocols and their performance is analyzed.

Keywords— Initial Energy, Protocol, LEACH, SEP, ZSEP.

I. INTRODUCTION

In a wireless sensor network, there can be many numbers of nodes which is used to transfer the information from sink to destination. The efficiency of the network depends on various parameters on the basis of requirement. Some of the important parameters which must be taken in consideration are energy consumption, throughput, packet delivery ratio and delay. Also depending on the requirement of the wireless sensor network, the network area is a very important parameter. The network area should be in sync with the initial energy given to the network so that energy consumption in the network can be reduced and throughput is increased. Also the routing protocol which is used in the network is an essential parameter as it is the set of rules which runs the network. Therefore depending upon the requirement, the right protocol must be chosen for the network so that the network runs efficiently [1].

II. PROTOCOL

In a network area which has large number of densely deployed sensor nodes, there is always a limitation of energy. Therefore, it requires a suite of network protocols that can be used to implement various management and

network functions which include network security, proper localization of nodes and synchronization. Therefore the comparative study of various protocols is necessary to analyze the better performance according to the requirements [2].

1. LEACH Protocol

LEACH [3] stands for Low Energy Adaptive Clustering Hierarchy. For reducing power consumption, it is the first proposed energy-efficient hierarchical clustering algorithm for WSNs. The operation of LEACH is divided in to two phases. First one is setup phase where network is organized into clusters, cluster head advertisement is done and transmission schedule is created. Second one is steady state phase where data is aggregated, then compressed and transmitted to the destination. In LEACH single hop routing is used where each node can transmit directly to cluster head or sink.

2. SEP Protocol

SEP [4] stands for Stable Election Protocol where the normal and advanced nodes are deployed randomly. If normal nodes are deployed in majority far away from the base station, the nodes will consume more energy in transmitting data to the base station which will result in less stability period and throughput. Therefore to overcome this, the network area is divided into regions where the far away nodes from base station that is the corners require more energy to transmit the data, so they are given more energy, called advanced nodes, in comparison to the nodes which are near to the base station and they are called normal nodes which directly send data to the base station.

3. ZSEP Protocol

ZSEP [5] stands for Zonal Stable Election Protocol which is an extension of SEP. It is an hybrid protocol in which on the basis of energy level and Y coordinate of the network field, the network area is divided into three zones namely zone 0, zone 1 and zone 2. In zone 0, normal nodes are deployed randomly, in head zone 1, half of the advanced nodes are deployed and in head zone 2, other half of the advanced nodes are deployed. ZSEP uses two techniques to transmit data to base station; one is direct

communication and second is transmission via cluster head. In direct communication, normal nodes in zone 0 sense and gather data of interest and directly send to the base station. In the second case, in head zone 1 and head zone 2, cluster head is selected among nodes in both zones, then cluster head sense and gather data, aggregate it and then send it to base station.

III. RELATED WORK

In WSN [1], the transmission range in sensor nodes are very limited, also as their energy resources are very limited so the performance and storage capabilities. In this paper, the survey for routing protocols for WSNs with the comparison of strengths and limitations is given. In WSNs [2], while designing protocol there is a limitation of node's energy, so energy efficiency is an important parameter to be considered. This paper proposes a new algorithm of LEACH protocol (LEACH-TLCH) which is considered to reduce the energy consumption and increase the network lifetime. In a WSN [3], the node is useful until its battery dies. In this paper, they analyze LEACH protocol, the advantages and disadvantages and various attacks on the protocol. In WSNs [4], the heterogeneity of nodes is introduced in terms of energy and they are hierarchal clustered. Protocols are designed for transmission [5] in WSNs. In this paper, for heterogeneous WSNs, they propose a hybrid routing protocol called ZSEP (Zonal Stable Routing Protocol). In this protocol, some nodes directly send data to base station while some use clustering technique to send data to base station as one in SEP. ZSEP performance is compared with LEACH protocol and SEP protocol. In [6], this paper analyses the energy utilization and lifetime analysis on the basis of LEACH protocol for the cluster based wireless sensor networks. In [7], this paper analyzes the performance of SEP and LEACH in terms of alive nodes and number of rounds for different base stations and terrain area. Network nodes die after more number of rounds if the base station is closer comparing the base station which is far away. In [8], for wireless multihop routing, this paper proposes linear programming model and they are examined over different routing techniques. In [9], the deployment strategy for wireless sensor network is presented for the gain of better strategy, computational power and transmission according to the required scenario.

IV. METHODOLOGY

In this paper, the nodes are deployed in a network field of area 100m X 100m. LEACH, SEP and ZSEP protocols are deployed in the network in heterogeneous environment. Initial energy is E_0 . The network area is kept constant and initial energy E_0 is varied. Here the goal is to study the impact of varying initial energy on the

performance of protocols on the basis of stability period and throughput under the influence of varying initial energy in the network keeping the network area fixed.

For LEACH, there are two phase, setup phase and steady state phase where steady state phase should be longer than setup phase. At the stage of cluster forming in LEACH, a random number is picked randomly between 0 and 1 by nodes. Now this number is compared to the threshold value $T(\alpha)$. If the number is less than this threshold value then that node becomes cluster head for this round otherwise it remains as common node. Threshold $T(\alpha)$ is determined by following;

$$T(\alpha) = \begin{cases} \frac{\mu}{1 - \mu * \left(r \bmod \frac{1}{\mu} \right)} \alpha \in \phi \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

Where, μ is the probability of each node to become cluster head, r is the number of the round; ϕ is the collections of the nodes that have not yet been head nodes in the first $1/\mu$ rounds.

In SEP, it is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. In this, the threshold for normal nodes and advanced nodes are given by following equations;

$$T(\alpha_{nrm}) = \begin{cases} \frac{\mu_{nrm}}{1 - \mu_{nrm} * \left(r \bmod \frac{1}{\mu_{nrm}} \right)} \alpha_{nrm} \in \phi' \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

Where, $\mu_{nrm} = \frac{\mu_{opt}}{1 + \beta m}$, is the weighted probability for normal nodes, r is the current round and ϕ' is the set of normal nodes that have not become cluster heads the last $1/\mu_{nrm}$ rounds of the epoch. μ_{opt} is the optimal probability. m is the fraction of advanced nodes and β is the additional energy factor between advanced and normal nodes.

$$T(\alpha_{adv}) = \begin{cases} \frac{\mu_{adv}}{1 - \mu_{adv} * \left(r \bmod \frac{1}{\mu_{adv}} \right)} \alpha_{adv} \in \phi'' \\ 0, & \text{otherwise} \end{cases} \quad (3)$$

Where, $\mu_{adv} = \frac{\mu_{opt}(1 + \beta)}{1 + \beta m}$, is the weighted probability for advanced nodes, r is the current round and ϕ'' is the set

of advance nodes that have not become cluster heads the last $1/u_{\text{adv}}$ rounds of the epoch.

In ZSEP, every node decides to become cluster head in current round or not by choosing a random number between 0 and 1. This number is then compared with a threshold value, if it is less the node becomes cluster head otherwise remain as normal nodes for this round. Threshold value is given by the following equation;

$$T(\alpha_{adv}) = \frac{\mu_{adv}}{1 - \mu_{adv} * \left(r \bmod \frac{1}{\mu_{adv}} \right)} \alpha \in \phi$$

$$0. \quad \text{otherwise} \quad (4)$$

Where, ϕ is the set of nodes which have not been cluster heads in the last $1/\mu_{adv}$ rounds. Probability for advance nodes to become cluster head which is

$$\mu_{adv} = \frac{\mu_{opt}}{1 + \beta m} \times (1 + \beta) \quad (5)$$

V. SIMULATION AND RESULT

The protocols are implemented in a field of network area 100m² in the presence of heterogeneity. The initial energy is 0.8J in the first simulation and then varied to 0.9J and 1.0J. For the case of $m=0.2$ and $\beta=1$, the simulation is performed in MATLAB. As the initial energy in the network field is varied, the performance of the protocols in respect of alive nodes, dead nodes and packets sent to base station is analyzed. As for $m=0.2$ and $\beta=1$, means that there are 20 advance nodes out of total nodes which are 100. In ZSEP, out of 20 advance nodes, 10 nodes are deployed in head zone 1 and other 10 nodes in head zone 2. The total number of rounds taken is 6000.

1. Simulation Parameters

Simulation scenarios in this article are given as below:

Table.1: Parameter Settings

Parameters	Value
Initial energy of advance nodes	$E_o(1+\beta)$
Energy for data aggregation <i>EDA</i>	5 nJ/bit/signal
Transmitting and receiving energy <i>E_{elec}</i>	5 nJ/bit
Amplification energy for short distance <i>E_{fs}</i>	10 pJ/bit/m^2
Amplification energy for long distance <i>E_{amp}</i>	0.013 pJ/bit/m^4
Probability μ_{opt}	0.1

2. Analysis of simulation results

Fig.1 indicates the total number of alive nodes in LEACH, SEP and ZSEP with respect to number of rounds

when initial energy is 0.8 J.

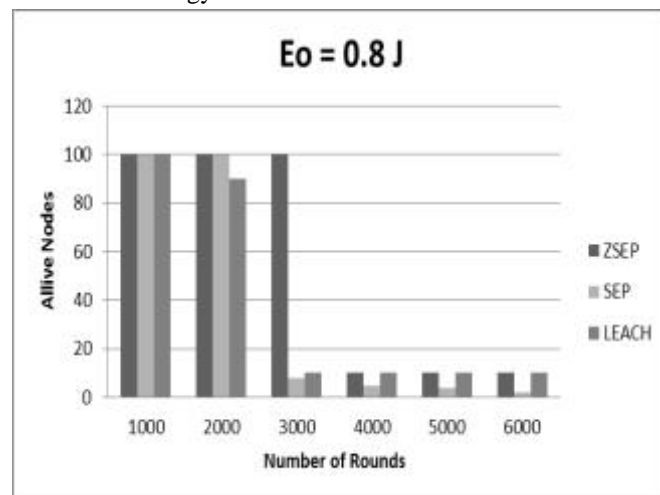


Fig.1: Result for alive nodes for $Eo = 0.8 J$

Fig.2 shows the scenario for total number of alive nodes in LEACH, SEP and ZSEP with respect to number of rounds when initial energy is 0.9 J.

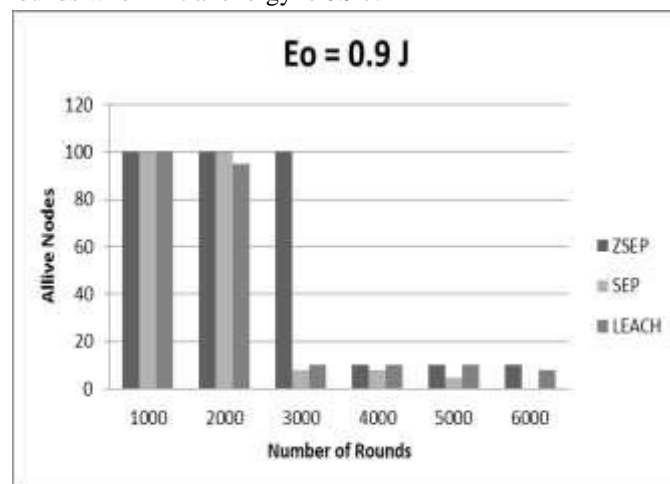


Fig.2: Result for alive nodes for $Eo = 0.9 J$

Fig.3 shows the scenario for total number of alive nodes in LEACH, SEP and ZSEP with respect to number of rounds when initial energy is 1J.

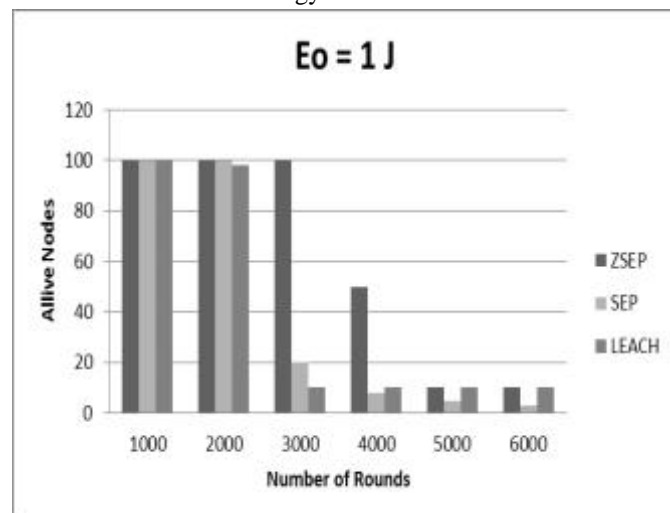


Fig.3: Result for alive nodes for $Eo = 1$ J

Fig.4 indicates the total number of dead nodes in LEACH, SEP and ZSEP with respect to number of rounds when initial energy is 0.8 J.

As the initial energy varies in the network, the number of alive nodes in the network also varies significantly. From Fig.1, Fig.2 and Fig.3, it can be seen that as the initial energy of the network increases, the stability period of the network in all the three protocols also increases. However ZSEP shows more stability in the network with the change in initial energy. ZSEP is performing better than the other protocols because of its network area divided into three zones. The nodes near to the base station directly communicate to the base station while the faraway nodes communicate to the cluster heads and cluster head sends data to base station. Because of this kind of setup the energy consumption is significantly low, and nodes sustain for longer period. While in SEP, there is shorter network lifetime because of the weighted probability for normal and advanced nodes in the network.

Fig.4 shows the scenario for total number of dead nodes in LEACH, SEP and ZSEP with respect to number of rounds when initial energy is 0.8J.

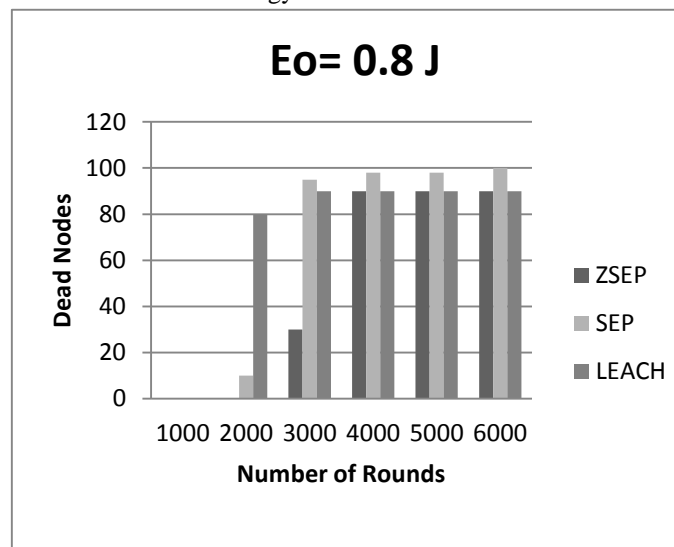


Fig.4: Result for dead nodes for $E_o = 0.8 J$

Fig.5 shows the scenario for total number of dead nodes in LEACH, SEP and ZSEP with respect to number of rounds when initial energy is 0.9J.

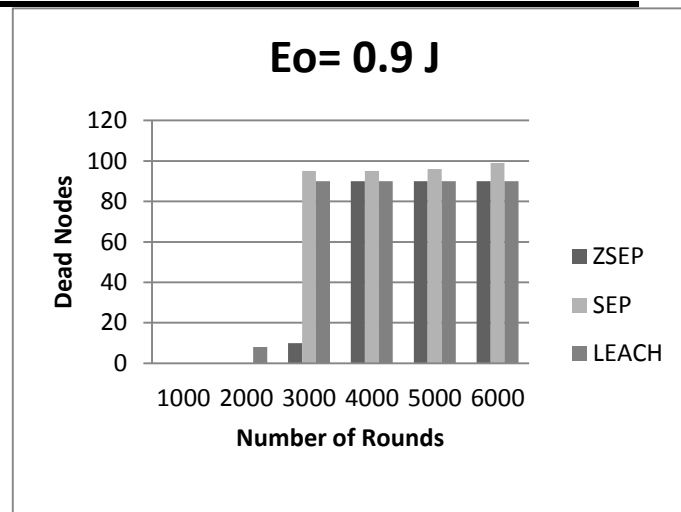


Fig.5: Result for dead nodes for $E_o = 0.9 J$

Fig.6 indicates the total number of dead nodes in LEACH, SEP and ZSEP with respect to number of rounds when initial energy is 1 J.

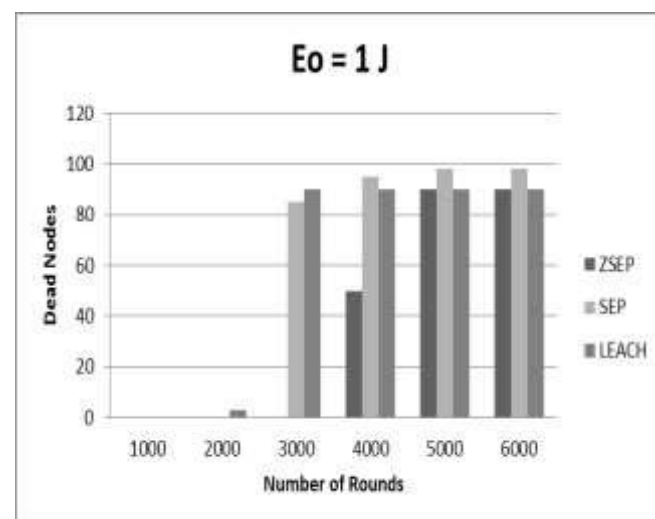


Fig.6: Result for dead nodes for $E_o = 1 J$

From fig.4, fig.5 and fig.6, it can be seen that as the initial energy increases in the network, the stability of each protocol increases for each rounds, in ZSEP, SEP and LEACH comparing the stability of nodes per round for different initial energy that has been taken. However if comparing the performance of protocols with each other , ZSEP still performs much better than others in terms of dead nodes per round. In between LEACH and SEP, LEACH performs better than SEP.

Fig.7 indicates the packets to base station in LEACH, SEP and ZSEP with respect to number of rounds when initial energy is 0.8 J.

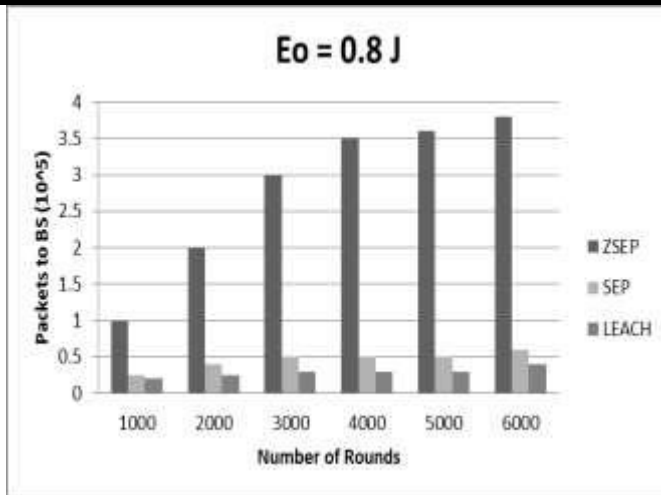


Fig.7: Result for packets to base station for $E_o = 0.8$ J

Fig.8 indicates the packets to base station in LEACH, SEP and ZSEP with respect to number of rounds when initial energy is 0.9 J.

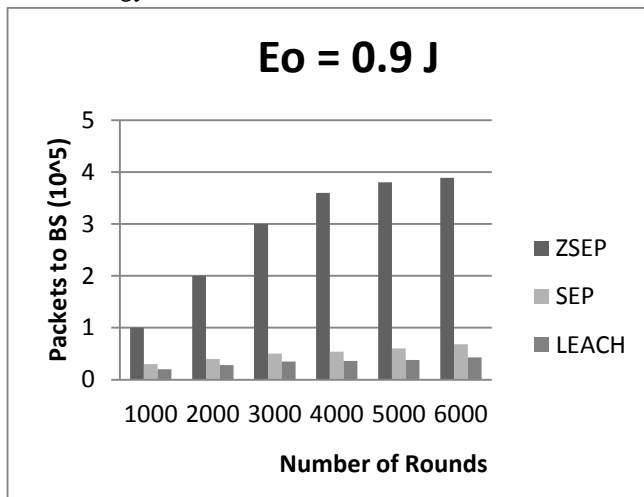


Fig.8: Result for packets to base station for $E_o = 0.9$ J

Fig.9 indicates the packets to base station in LEACH, SEP and ZSEP with respect to number of rounds when initial energy is 1 J.

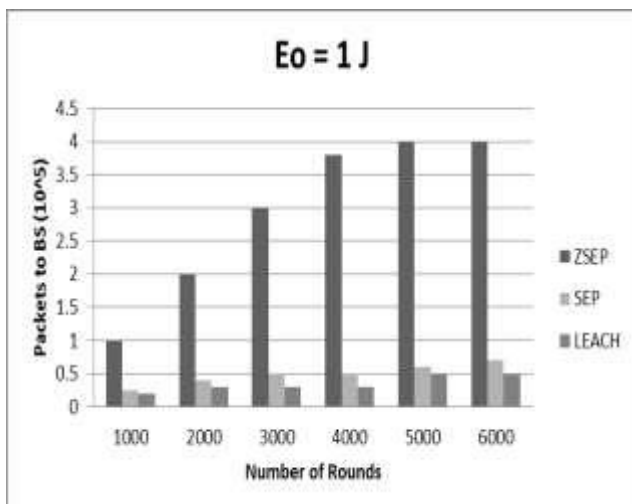


Fig.9: Result for packets to base station for $E_o = 0.9$ J

From Fig.7, Fig.8 and Fig.9, we can analyze the result for number of packets to base station for every round in each protocol. The value increases as the initial energy increases and also the stability for each protocol increases in the network. However, ZSEP is still performing better than other protocols SEP and LEACH. In SEP and LEACH, SEP is performing better than LEACH. As in LEACH there is an equal probability of each node to become cluster head, therefore the advanced nodes become cluster head again after completion of a round, and the normal nodes are not able to perform better in case of data aggregation and transmissions to the base station when they become cluster head. It causes decrease in the number of packets transferred to the base station. While in SEP, there is a system for weighted election probability for advanced and normal nodes.

VI. CONCLUSION

When the initial energy in the network is increased without varying overall network area, there is a significant effect on the performance of protocols implemented in the network. The stability of each protocol increases as the time taken by nodes to sustain increases with increase in number of rounds. Also the number of packets transferred to base station in each round increases. The performance of ZSEP is better than LEACH and SEP, while in terms of number of packets transferred to base station, SEP is performing better than LEACH. It concludes that there should be some trade of or synchronization between the protocols that is being implemented in the network and the initial energy that is being provided. Also, not all the protocols perform similar in the same environment. Therefore it is very necessary to choose a protocol according to the requirement for which the wireless network is being setup in an environment.

REFERENCES

- [1] Shio Kumar Singh, M P Singh, and D K Singh "Routing Protocols in Wireless Sensor Networks –A Survey" In: International Journal of Computer Science & Engineering Survey (IJCSES) Vol.1, No.2, November 2010.
- [2] Chunyao FU, Zhifang JIANG, Wei WEI and Ang WEI "An Energy Balanced Algorithm of LEACH Protocol in WSN" In: IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 1, No 1, January 2013.
- [3] Reenkamal Kaur Gill, Priya Chawla, Monika Sachdeva "Study of LEACH Routing Protocol for Wireless Sensor Networks" 2014 International Conference on Communication, Computing & Systems (ICCCS-2014).

- [4] Georgios Smaragdakis, Ibrahim Matta and Azer Bestavros “SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks” In Proceeding of the International Workshop on SANPA, August 2004.
- [5] S. Faisal1, N. Javaid, A. Javaid, M. A. Khan, S. H. Bouk, Z. A. Khan “Z-SEP: Zonal-Stable Election Protocol for Wireless Sensor Networks” In: Journal of Basic and Applied Scientific Research, Vol. 3, No.5, 2013.
- [6] Abdul Sattar Malik and Suhail A. Qureshi “Analyzing the Factors Affecting Network Lifetime for Cluster-based Wireless Sensor Networks” In: Pak. J. Engg. & Appl. Sci. Vol. 6, pp. 9-16, Jan., 2010.
- [7] Upasana Sharma, Sunil Tiwari “Performance Analysis of SEP and LEACH for Heterogeneous Wireless Sensor Networks” In: International Journal of Computer Trends and Technology (IJCTT), Vol. 10 No. 4, Apr 2014.
- [8] N. Javaid, R. D. Khan, M. Ilahi, L. Ali, Z. A. Khan, U. Qasim, ”Wireless Proactive Routing Protocols under Mobility and Scalability Constraints”, J. Basic. Appl. Sci. Res., 3(1)1187-12001, 2013.
- [9] Jasvinder Singh, Er. Vivek Thapar, Er.Amit Kamra “Deployment Strategy of Homogeneous and Heterogeneous Wireless Sensor Network” In: International Journal of Computer Science and Communication Engineering, Volume 1, Issue 2, 2012.